COMPLEMENTARY ROLES OF NATURAL GAS AND COAL IN MALAYSIA

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1 INTRODUCTION

This paper looks at the development of coal and gas fired generation in the Peninsula Malaysia power sector. While Malaysia has large resources of indigenous gas, security of supply and stable and competitive prices have justified a need to review the energy mix focusing on increasing coal generation capacity.

2 FOUR FUEL DIVERSIFICATION STRATEGY

Since 1980, the Malaysian energy sector has been guided by the four-fuel diversification strategy. This strategy was formulated in the aftermath of the two international oil crisis and quantum leaps in prices in 1973 and 1979, and during which time the Malaysian energy sector had been highly dependent on a single source of energy, namely oil. Faced with prospect of Malaysia quickly becoming a net importer of oil, and the possibility of prolonged energy crisis, the government called for the diversification of energy resources away from oil, to develop more hydropower, and to use more natural gas and coal. At that time there were large untapped indigenous hydropower and natural gas reserves, while coal was considered an abundant worldwide resource having more stable prices because of it being usually traded on contracts rather than in the spot market. As a direct result of this strategy, Malaysia has drastically tipped the balance in the fuel mix in energy consumption from a high 90% dependence on oil in 1980 to less than 64% in 1997. Natural gas and coal, in 1997, accounted for 30% and 5% respectively of the total energy mix.

This policy was largely pursued in the electricity generation sector, through the construction of open and combined cycle gas turbines, dual-fired gas/oil thermal power stations, coal-fired thermal power stations and hydroelectric power stations. In 1999, the fuel mix for electricity generation was 73.3% natural gas, 7.8% petroleum products, 7.5% coal and 11.4% hydro.

Natural gas for domestic consumption is indigenous and sourced from the gas and oil fields in the South China Sea in Terengganu, but the bulk of coal requirements were imported. The latter are sourced from Australia, South Africa, Indonesia and China though some domestic coal was used in blending.

High prices need not be the only reasons for maintaining the four-fuel diversification. Security of supply through diversification is just as important in energy policy. With a balanced energy mix, the economy and particularly the power sector is less vulnerable to shocks in the fuel supply.

3 COAL

3.1 General

Malaysia has a coal mining history dating back as far as 1851. The coal resource of Malaysia to date is estimated at about 1,050 million tonnes of various qualities ranging from lignite to anthracite; bituminous to sub-bituminous coal, however forms the bulk of this amount. The known resource may be classified into 231.85 million tonnes proven reserve; 171.38 million tonnes indicated reserve and 646.84 million tonnes inferred reserve. Of the total amount, about 69% are found in Sarawak, 29% in Sabah and 2% in Peninsular Malaysia (see Table 1). Most of these known coal areas are located inland where infrastructure is poor. The coal resource in Peninsular Malaysia is negligible.

The coal resource available both in Sabah and Sarawak is substantial. Development of the known coal resource of the country should be sufficient to supply a large portion of this demand. The major constraint at the moment is that the deposits are located in the interior where infrastructure is lacking.

Development cost of these deposits is high. Furthermore, a large portion of these deposits is only amenable to underground mining, which costs more. Coal is also facing stiff competition from other economies with bigger coal reserves and a better-established coal industry. However, Malaysian coal with low ash and sulphur contents has the potential of being a premium fuel if it can be delivered to the end users at a competitive price.

The present coal production comes from Global Minerals (S) Sdn Bhd mine at Merit-Pila Coal Field, which in 1999 produced a total of 291,112 tonnes. Luckyhill Mining Sdn Bhd, which operates a modest underground mine at Silantek, produced 15,191 tonnes and Luckyhill Coal Mining Sdn Bhd at Abok produced 2,200 tonnes.

The total coal consumption in 1998 was 3 million tonnes of which 1.7 million tonnes were used by the power stations while the cement industry used 1.3 million tonnes. Virtually all of the coal was imported.

Coal utilisation mainly as fuel for power plants is expected to increase significantly from about 4.2 million tonnes in the year 2000 to about 13 million tonnes in 2005. The increase is due to commissioning of new coal fired power stations and the government licensing of IPP. Consumption by the cement industry is also expected to increase from about 1.8 million tonnes in the year 2000 to about 2 million tonnes in 2005. Thus the demand for coal by 2005 is forecast to be 15 million tonnes per annum.

TABLE 1 KNOWN COAL RESOURCES IN MALAYSIA (IN MILLION TONNES)

LOCATION	**RESERVE**			**COAL TYPE**
	Measured	**Indicated**	**Inferred**	
SARAWAK				
1. Silantek	7.25	10.60	32.40	Coking coal semi-anthracite, anthracite
2. Merit-Pila	176.20	107.08	121.84	Sub-bituminous
3. Bintulu	-	-	120.00	
4. Mukah-Balingan	43.60	8.30	98.10	
Sub-total	***227.05***	***125.98***	***372.34***	
SABAH				
1. Silimpopon	4.80	1.50	7.70	Sub-bituminous
2. Labuan	-	-	8.90	Sub-bituminous
3. Maliau	-	-	215.90	Bituminous
4. Malibau	-	17.90	25.00	
5. SW Malibau	-	26.00	-	
	4.80	***45.40***	***257.5***	
PENINSULAR				
1. Batu arang	-	-	17.00	Sub-bituminous
Sub-total	-	-	***17.00****	
Grand Total	**231.85**	**171.38**	**646.84**	

* 15 mt already mined out.

4 GAS

4.1 Reserves

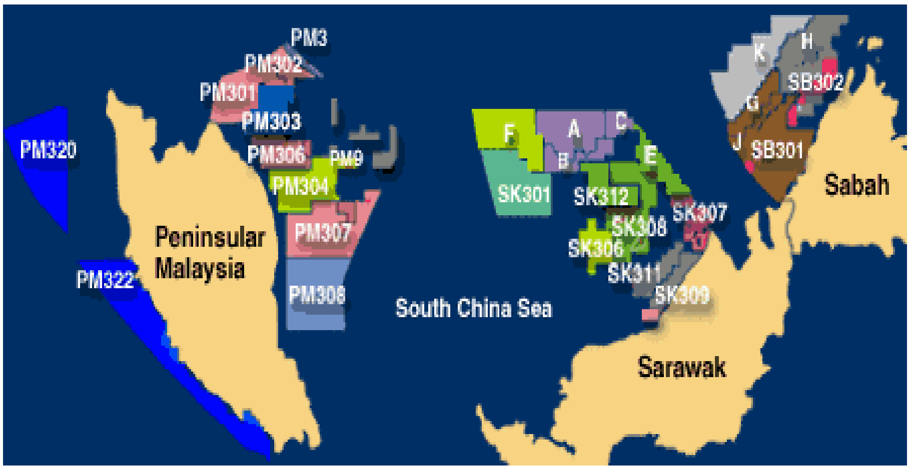

FIGURE 1 MALAYSIAN PRODUCTION SHARING CONTRACT AREAS

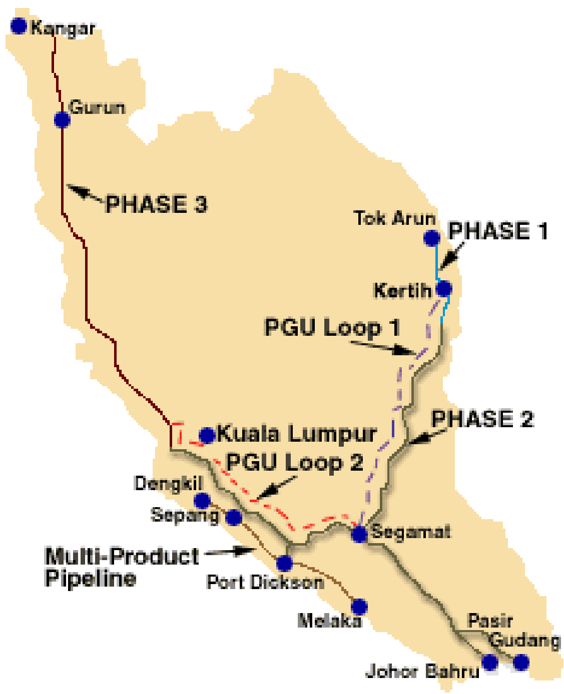

FIGURE 2 THE PGU GAS RETICULATION SYSTEM

Malaysia has gas reserves totaling 87 TCF. Proven reserves total 58 TCF. West Malaysian reserves are 36.6 TCF, the East Malaysian states of Sarawak have 44.3 TCF and Sabah has 6.1 TCF. Figure 1 shows the production sharing contract areas for Malaysia. About 61% of gas produced is exported as LNG, 3.5% exported via pipeline and 35.5% is for domestic utilisation.

4.2 Gas Infrastructure Development

Gas is supplied via a gas reticulation system installed by the national petroleum company, PETRONAS, under the Peninsula Gas Utilisation Project. Phase 1 (PGU I) which was completed in 1984 (Figure 2). This comprised of a gas processing plant (GPP 1) with a capacity of 250 mmscfd installed at Kertih, Terengganu. The system comprised of 32 km of pipeline leading to an export terminal and power and industrial users in the east coast of Peninsula Malaysia.

The completion of the 714 km PGU II pipeline system in 1992, with the addition of GPPs 2, 3 and 4 boosted gas volumes to 1000 mmscfd (or 4x250 mmscfd per GPP).

The completion of PGU III in 1998 with the addition of 450 km of pipeline northwards along the west coast to the Malaysian-Thailand border, and the addition of GPP 5 and 6 (500 mmscfd each) has provided additional volumes of gas and has allowed for a more stable gas supply grid. This has significantly improved gas availability. PETRONAS will further enhance transmission capacity by reinforcing the central main line with PGU Loop 1 and PGU Loop 2 to be completed by early 2001. In addition, by 2001, the volume of gas available will reach 2000 mmscfd with the addition of new Malaysian fields. Additional gas from the MTJDA fields (Figure 3) will provide security of supply and meet new demand. Figure 4 shows the growth of Malaysia's Natural Gas Processing Facility for the PGU System between 1984 and 1999.

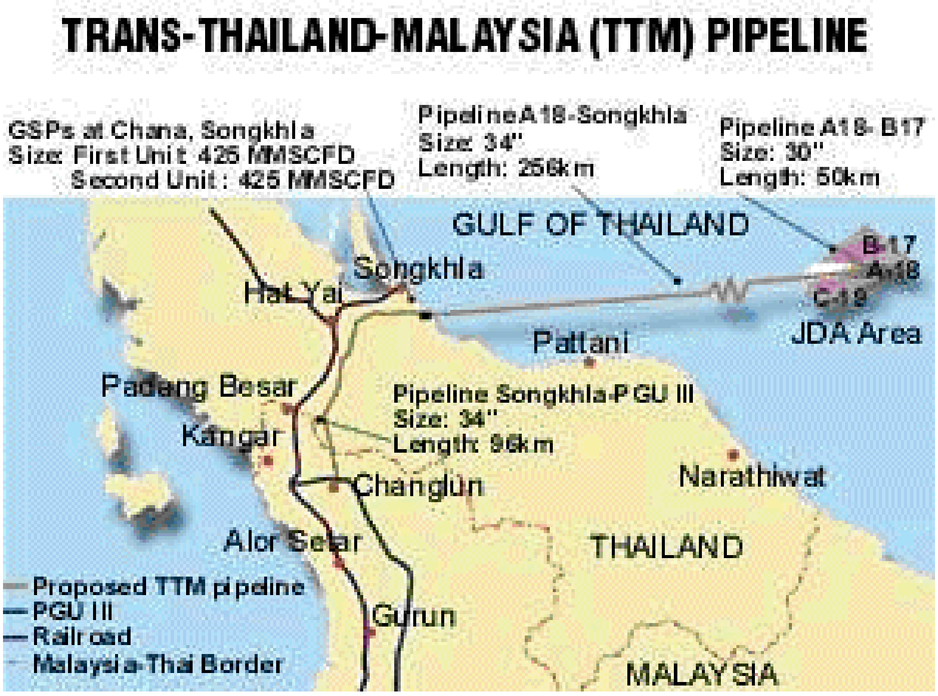

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FIGURE 3 MALAYSIA THAILAND JOINT DEVELOPMENT AREA (MTJDA)

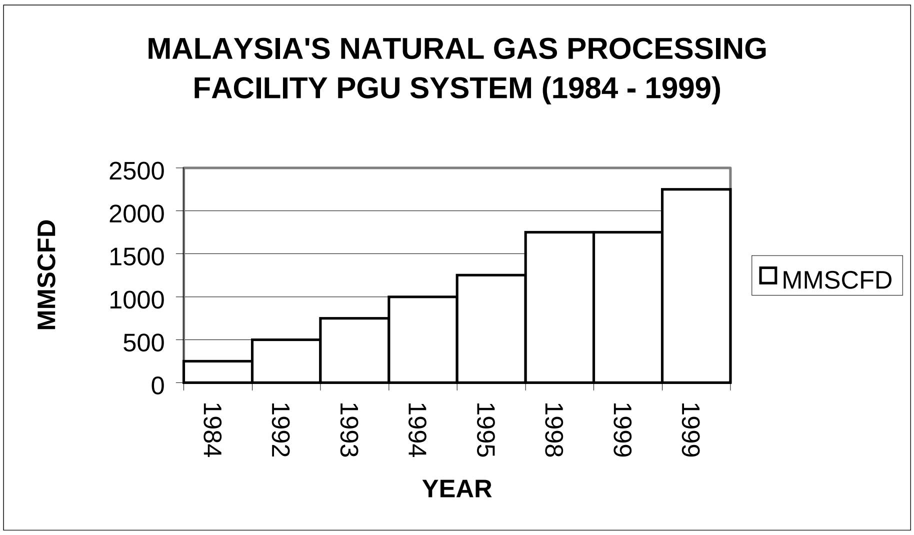

FIGURE 4 MALAYSIA'S NATURAL GAS PROCESSING FACILITY PGU SYSTEM (1984 - 1999)

5 THE PENINSULA MALAYSIA ELECTRICITY SECTOR

The total installed generation capacity in Peninsula Malaysia as of 1 September 1999 approximated 12,000 MW with a peak demand of about 8,800 MW. The electricity generation industry in Malaysia now operates in a privatized environment. Of the total installed capacity, 4474MW (37%) is owned and operated by five Independent Power Producers (IPPs). The entry of IPPs have taken a substantial slice of the generation market share from Tenaga Nasional Berhad (TNB), which prior to 1992, had a complete monopoly of the electricity supply industry. As of 1 September 1997, TNB have also moved away from direct involvement in power generation when all of its power stations (12 numbers) were leased to its wholly owned subsidiary, TNB Generation Sdn. Bhd. (TNBG). Most of the IPPs operating in Malaysia were developed on non-recourse financing arrangement, where cost and performance management becomes a prime concern to the developers in order to ensure adequate return to the developers after debt repayment. Fuel is a pass-through cost to TNB as Offtaker in the Power Purchase Agreement (PPA).

In 1999, the fuel mix for electricity generation was 73.3% natural gas, 7.8% petroleum products, 7.5% coal and 11.4% hydro.

5.1 Development of Power Sector Gas Demand

Malaysia’s first gas turbine power station at Paka, Terengganu was commissioned in 1984. By 1986 all open-cycled units (6x95MW) were converted to combined-cycle units with the addition of 3x100 MW steam turbines. The power station now has a total capacity of 1124 MW with gas consumption at 227 mmscfd.

By 1992, gas was piped to power plants at no cost to the power utility, Tenaga Nasional Berhad (TNB), whilst TNB followed the concept of fuel switch ability by converting gas turbine plants and thermal plants in western and southern parts of West Malaysia to also use gas. At the same time the electricity supply industry in West Malaysia was partly liberalized with the introduction of Independent Power Producers (IPPs). There were five IPPs with a total installed capacity of 4115 MW of gas turbine plants either in open-cycle or combined cycle configuration.

- YTL Power Generation Bhd. (1212 MW)
- Segari Energy Ventures Sdn. Bhd. (1303 MW)
- Genting Sanyen Power Sdn. Bhd. (720 MW)
- Powertek Bhd. (440 MW)
- Port Dickson Power Sdn. Bhd. (440 MW)

As with all new gas pipeline systems the reliability of gas supply had to be proven with time. In the early years power plant flexibility with fuels tolerated gas supply interruptions, but at the cost of using more expensive fuels such as distillate. Distillate storage facilities were required as standby fuel incase of gas supply disruption.

5.2 Power Generation Fuel Mix

West Malaysia’s generation capacity has since grown from 6030 MW in 1990 to 11,994 MW in 1999, with the IPPs now contributing 4474 MW or 37.3% of total capacity. Gas constitutes about 73% of the generation fuel mix. The current nomination capacity for gas totals 884 mmscfd for TNB and 858 mmscfd for the IPPs. The total power sector demand is therefore 1741 mmscfd. Fuel Oil has been displaced by gas, and the oil consumption is now about 600,000 MT/year compared to 2.3 million MT/year in 1997. By 2004, fuel oil consumption is expected to be below 200,000 MT/year.

From an operational point of view, gas provided a welcomed replacement for fuel oil fired gas turbines (at Connaught Bridge Power Station) where machine availability and reliability improved dramatically as a result of gas conversion. There was no more a need for frequent turbine blade washing, and blade replacement intervals were extended. Other power plants with dual fuel capability could easily switch between gas and oil or coal when economically justifiable or when a fuel supply feed posed a problem.

The fuel mix is based on a fuel policy that looks at security of fuel supply and the cost of fuel. The power generation mix over the next ten years is shown in Figure 5.

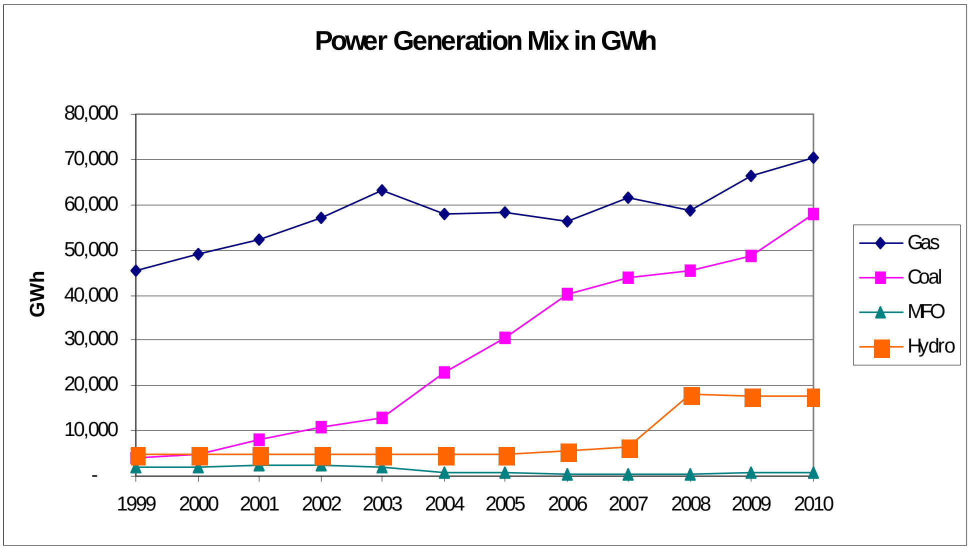

FIGURE 5 POWER GENERATION MIX IN GWH

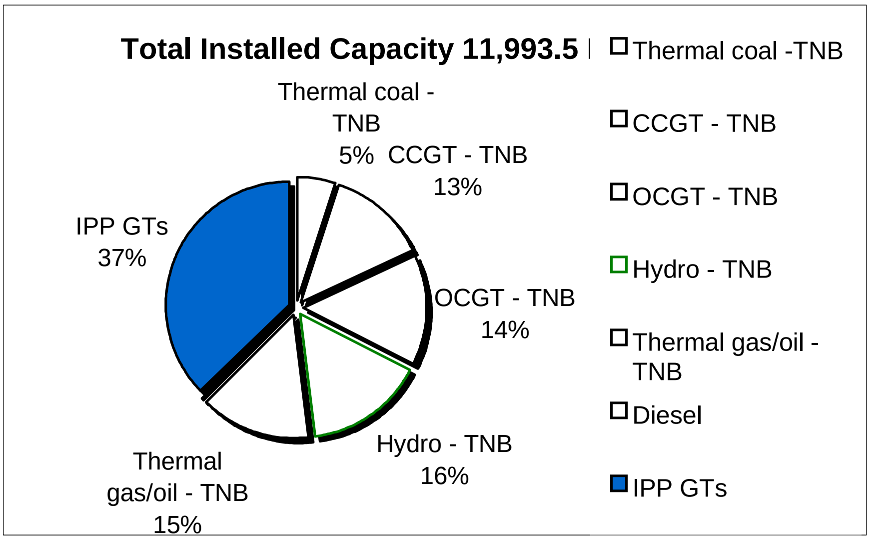

FIGURE 6 TOTAL INSTALLED GENERATION CAPACITIES IN PENINSULAR MALAYSIA (1999)

TABLE 2 TOTAL INSTALLED CAPACITY (MW) IN 1999, PENINSULAR MALAYSIA

Type	Fuel	Capacity (MW)	Percentage (%)
Conventional Thermal	Coal	600	5.00
Conventional Thermal	Oil/Gas	1,751	14.60
Combine Cycle	Gas	1,557	12.98
Gas Turbine	Gas	1,728	14.41
Hydro	-	1,873.5	15.62
Diesel	Diesel	10	0.09
Total TNB		7,519.5	62.70
Total IPPs	Gas	4,474	37.30
Total Installed Capacity		11,993.5	100

TABLE 3 - EXISTING AND PLANNED COAL-FIRED POWER PLANT 2000 - 2010

Existing and Planned Coal-Fired Power Plant 2000 - 2010			
Plant	Capacity	Completion	Coal Utilization
TNB Kapar Ph. 2	600 MW	1988	1.5 mtpa
TNB Kapar Ph. 3	1000 MW	2000	2.5 mtpa
TNB Janamanjung	2100 MW	2002/03	6.0 mtpa
SKS - IPP	2100 MW	2004/05	6.0 mtpa
Jimah - IPP	1400 MW	2005/06	3.0 mtpa
Total	7200 MW		19.0 mtpa

TABLE 4 YEARLY REQUIREMENT FOR ADDITIONAL GAS BETWEEN 2002 AND 2010

	Year	**Additional Gas Requirement in MW**	**Additional Gas Requirement MMSCFD**
1	2002	1616	404
2	2003	1220	305
3	2004	0	0
4	2005	440	110
5	2006	0	0
6	2007	220	55
7	2008	1200	300
8	2009	660	165
9	2010	900	225
TOTAL		**6256**	**1564**

TABLE 5 EXISTING GAS-FIRED GENERATION CAPACITY

Gas Fired Plants	**Units**	**Capacity MW**	**Gross Capacity MW**	**Max Daily Quantity MMSCFD**
Kapar (phase 1)	2	300	600	138
Connaught Bridge CC	1	300	300	61
Paka	4	556	1124	227
Port Dickson	3	120	360	93
Pasir Gudang	5	413	557	131
Prai	3	144	178	52
Serdang	5	240	610	168
Total TNB Baseload	**26**	**2183**	**4059**	**935**
Total TNB Peak Load	**16**		**1926**	**524**
Total IPP (base & peak)			**4474**	**858**
TOTAL			**10,459**	**2317**

6 ENVIRONMENTAL IMPACT

Proposed constructions of power plants is a prescribed activity under Activity 13a of the Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987 made under Section 34A of the Environmental Quality Act 1974. It stipulates that an Environmental Impact

Assessment (EIA) study is mandatory for the construction of steam generated power stations burning fossil fuels and having a capacity of more than 10MW. The EIA report has to be approved prior to commencing construction and physical activities.

In the development of new power plants, due consideration will be given to the environment and public acceptance, inherent with the planting up of such facilities. In addition, due diligence will be paid to maintain the ecological balance in and around the vicinity. For power stations sited near the sea, creation of significant opportunities for marine related aquaculture farming and eco-tourism would also be considered.

Prior to carrying out the study, the Terms of Reference (TOR) for the detailed EIA study is submitted for approval in principle by the Department of Environment (DOE) Panel. The purpose of the TOR is to describe the requirements for an EIA study and for the preparation of an EIA report in accordance with guidelines prescribed by the DOE. A detailed EIA study to comply with DOE approved TOR will then be conducted and all mitigation measures recommended in the report and conditions imposed by the DOE will be implemented fully. A public notice advertisement will also be placed in the local dailies to invite the public, professionals and interested parties to comment on the TOR and to sit on the inquiry panel to be set up.

Subsequently, the completed detailed EIA Report shall be submitted to the DOE and then opened for public inspection and comments.

7 TECHNOLOGY EMPLOYED

The EIA is used as the environmental control standard from which to operate the power plants. The factors, which are monitored in compliance with the EIA, are, particulate matter (PM), CO_2, SOx and NOx emissions, Noise levels, and effluent discharge and smoke density.

The single coal plant that exists now in Malaysia has Electrostatic Precipitators (ESP) and low NOx burners installed. Particulate Matter discharge is limited to 400mg/m^3. Future coal plants will require Flue Gas Desulphurizers (FGD) as a standard requirement.

The general principles towards application of new technology follow the guidelines of retirement of inefficient units, bigger sized plants, retrofitting, repowering and refurbishment of plants.

8 RESTRUCTURING & PRIVATIZATION IN THE POWER SECTOR

The first step in the restructuring process was to privatize the power utility in 1992. In the same year IPPs were introduced. The IPP choice over the last eight years has been gas turbine plants. The relatively low capital costs for construction, higher efficiency and the shorter lead times, coupled with the need for accelerated plant-up schedules, have been some of the major factors contributing to this trend. The availability of gas has also helped promote the use of gas turbines.

The next ten years sees the introduction of many coal plants, bringing the coal component in the fuel mix to approximately 39.5%. These plants will be IPP plants. The abundance of coal resources and readily available supply, coupled with the introduction of affordable new clean technologies will help Malaysia rebalance its generation fuel mix. Coal plants also provide the robustness required in maintaining a stable electricity supply grid.

9 COAL AND GAS PRICE

Coal prices are currently based on bilateral negotiations with reference to benchmark prices. Coal prices have been relatively low and stable. Gas prices on the other hand are seen to be increasing. New offshore gas fields are further and deeper, and are costly to develop.

The issue of future gas price is of significant importance in this regard. Whilst gas price in West Malaysia was indexed to fuel oil in the Gas Supply Agreements, there was a need for the Malaysian Government to fix the price of gas in May 1997 at RM6.40/MMBTU until 31 December 2000 in view of electricity tariff regulation. The price of gas from 1.1.2001 has yet to be decided. Whilst gas has managed to displace fuel oil in the generation fuel mix, coal provides the next challenge to gas. Coal is priced much lower than fuel oil and the future plant-up program indicates a dramatic growth in coal fired generation plants.

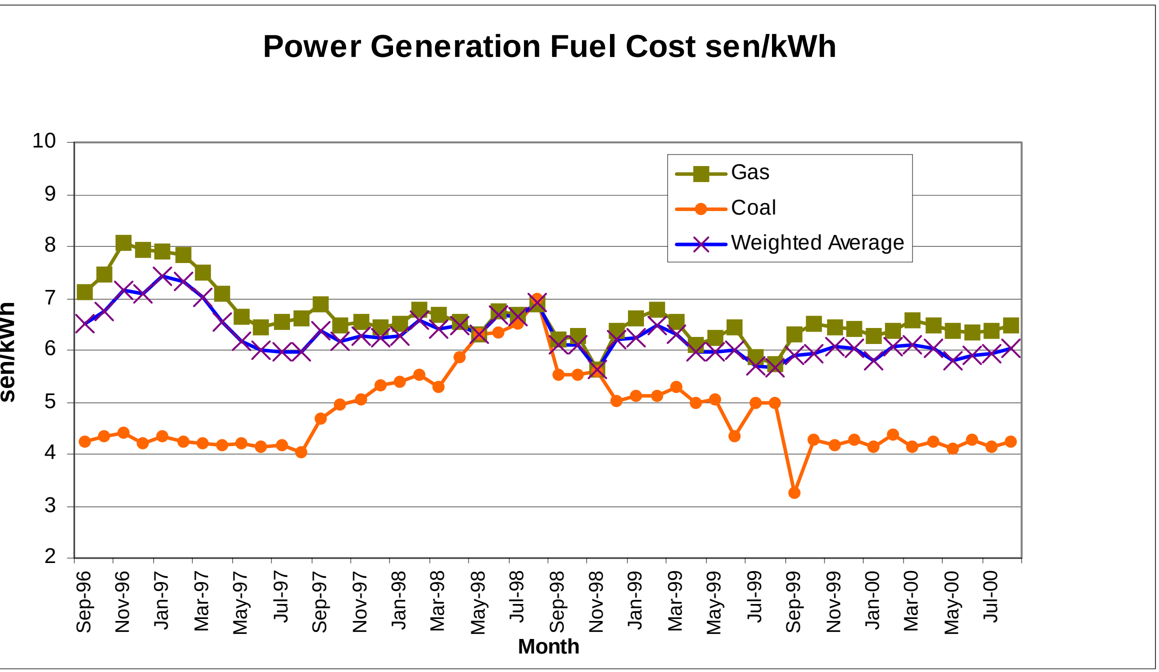

FIGURE 7 POWER GENERATION FUEL COST SEN/KWH
(NOTE: 3.80 SEN = 1.0 US CENT)

An issue that needs to be addressed is the nature of gas supply contracts. Absence of a variety of gas suppliers, gas supply agreements has a tendency to become risk averse. High take-or-pay requirements run contrary to the electricity deregulation process where plants are fully despatchable. It is hoped that with the focus on establishing a Trans Asean Gas Grid the surplus gas envisaged will open the doors for a more dynamic gas supply industry with market oriented pricing and reasonable contractual terms.

10 CONCLUSIONS

Fuel oil, which was once the dominant fuel for electricity generation in Malaysia, is now virtually phased out of the fuel mix. At present, nuclear would not be considered as an alternative fuel. Hydro has limited resources left for new development in Peninsula Malaysia.

This leaves gas and coal to be dominant in the fuel mix for power generation. The use of imported coal with stable prices and abundant supply is complementary to domestic gas, as it would optimise the development of domestic gas resources.

Sultan Salahuddin Abdul Aziz Power Station (SSAAPS)

INDICATIVE DESIGN COAL RANGE

GENERAL				
	UNITS	BASIS	GF2	GF3
Gross Calorific Value	kcal/kg	ADB	6,350 min	6,350 min
(Specific Energy) kJ/kg			26,586	26,586
Total Sulphur	%	ADB	0.3 – 1.0	0.26 – 0.92
Hardgrove Index			45.0 min	40.0 min
Size	mm		50.0 max	50.0 max
% passing 3 mm sieve	%		30.0 max	30.0 max
Fuel Ratio (FC: VM)			1.3 – 2.4	1.1 – 2.3
ASH FUSION TEMPERATURE (REDUCING)				
Initial deformation	^oC		> 1200	> 1240
Hemisphere	^oC		> 1320	> 1360
Flow	^oC		> 1350	> 1400
PROXIMATE ANALYSIS				
Total Moisture	%	AR	18.0 max	18.5 max
Ash	%	AR	18.0 max	17.5 max
Volatile Matter	%	ADB	> 24.0	> 25.0
Fixed Carbon	%	ADB	45.0 – 58.0	43.5 – 57.5
ULTIMATE ANALYSIS (D.A.F)				
Carbon	%		77.9 – 86.5	72.3 – 84.6
Hydrogen	%		4.4 – 6.0	1.1 – 6.2
Nitrogen	%		0.8 – 2.1	1.1 – 2.2
Oxygen	%		7.5 – 15.0	8.2 – 15.9
Sulphur	%		0.3 – 0.83	0.37 – 1.1
Phosphorus	%		0.008 – 0.4	0.008 – 0.4
Chlorine	%		0.03 – 0.13	0.03 – 0.13
ASH ANALYSIS (D.M.M.F)				
SiO_2	%		47.5 – 76. 9	45.0 – 80.0
Al_2O_3	%		17.0 – 37. 5	14.0 – 41.34
Fe_2O_3	%		0.52 – 10.34	0.52 – 11.50
CaO	%		0.12 – 5.57	0.12 – 9.00
MgO	%		0.15 – 2.23	0.15 – 3.95
TiO_2	%		0.50 – 2.18	0.60 – 3.10
Na_2O	%		0.14 – 2.43	0.10 – 2.12
K_2O	%		0.24 – 1.59	0.20 – 1.90
Mn_3O_4	%		0.01 – 0.10	0.01 – 0.10
P_2O_5	%		0.15 – 1.30	0.15 – 1.30
SO_3	%		0.02 – 4.17	0.02 – 4.17

Note:	1.0 kcal	=	4.1868 kJ
	1.0 Btu / lb.	=	kcal/kg x 1.8
	AR	=	As Received Basis
	ADB	=	Air Dried Basis
	DMMF	=	Dry Mineral Matter Free

FUEL OIL QUALITY

Quality Parameters	Standard & Methods		Quality Specifications
	I.P	ASTM	Min/Max
Gross Calorific Value (Btu/lb)	12/73	D240	18,350 (Min)
Sulphur (wt %)	242	D4249	3.5 (Max)
Kinematic Viscosity (cst, 50^{o}C)	71/87	D445	180 (Max)
Flash Point PMCC (^{o}C)	34/85	D93	66 (Min)
Ash (wt%)	4/81	D482	0.10 (Max)
Pour Point (^{o}C)	15/67	D97	21 (Max)
Conradson Carbon Residue (wt %0	13/82	D189	13 (Max)
API Gravity at 60/60 ^{o}C		D287	13 (Min)
Density (kg/litre, 15^{o}C)	160/68	D1298	0.98 (Max)
Vanadium (ppm wt)	285/79	D1548 or AAS	80 (Max)
Sodium plus Potassium (ppm wt)	285/74	AAS	80 (Max)
Sediment by Extraction % wt	53/70	D473	0.10 (Max)
Water by Distillation % wt	74/70	D95	0.5 (Max)
Asphaltenes % wt	143/84	D3279	5 (Max)

GAS QUALITY

CRITERIA	VALUE
Minimum Gross Heating Value	35.1 MJ/ Sm^3
Maximum Gross Heating Value	48.1MJ/ Sm^3
Maximum Specific Gravity	0.75
Maximum Sulphur Content	5.7 mg / Sm^3
Maximum Hydrocarbon Dew Point	10^{o} C at 5,600 kPag
Maximum Water Dew Point	10^{o} C at 5,600 kPag
Maximum Delivered Temperature	55^{o} C
Minimum Delivery Pressure	2,150 kPag
Maximum Delivery Pressure	2,600 kPag